Chapter 7 – Decision Processes

Objective

Achieving BED's overarching twin objectives (i.e., 218c compliance and helping Burlington transition to Net Zero Energy) in an uncertain world will be challenging. Multiple known and unknown risks about the state of our economy, public health, technology, regulations, and wholesale market prices for energy, capacity, transmission, and RECs must be considered when making decisions. A decision process that adequately recognizes and accounts for a range of future risks when making a decision is critical. In this chapter, we describe our process for evaluating risks and making decisions using Behind-the-Meter ("BTM") storage as an example.

Our objective in providing the example analysis below is to describe to the Commission our analytical methods for identifying and evaluating the known risks associated with a utility-scale energy storage system in Burlington. We then explain how BED would decide whether to proceed with such an investment based on the best available information. After the detailed BTM example, we discuss the decision tree methodology that we would use in the context of a series of choices that may need to be made concurrently.

Burlington's (and Vermont's) goals are currently focused on reducing the many adverse impacts of climate change. However, BED believes that having attained 100% renewability in the energy supply for BED, and with BED's goal of meeting its Tier 3 RES obligation with electrification programs rather than by simply buying RECs, the decisions with regard to climate change will, in large part, be made outside the utility space. Decisions regarding how to address climate change are expected to occur over the next two to three years, particularly if Burlington and Vermont are going to achieve aggressive climate goals. BED will just be one party among many involved in these discussions. BED does expect to need to be able to model potential impacts of new ordinances, statutes, and rules and believes that the work done in this IRP positions us well to do so (see Net Zero Chapter for additional discussion of potential impacts of the early stages of the Roadmap). As noted elsewhere in this IRP, BED is evaluating one plausible, forward-looking scenario: a NZE future. The potential impacts of this scenario are discussed in greater detail in the Net Zero Energy Chapter. The next series of actions required to realize such a future rests largely outside of BED's control. Consequently, BED does not anticipate making any 248 filings soon.

Sample Single Decision Analysis: BTM Energy Storage

To illustrate BED's decision-making process, a sample energy storage purchased power agreement ("PPA") for a 5MW/20MWh Lithium ion battery located in Burlington is analyzed below. Energy storage has long been a resource upon which New England has relied in the form of nearly 2 GW of pumped hydro capacity[1] that has been balancing the grid for over forty years. Recent energy storage price declines for battery storage, as well as an anticipated need for additional storage due to increasing intermittent generation, have led to a revival of interest where numerous customer-sited batteries are being installed and ISO-NE now has 2GW of storage in its interconnection queue. BED has been exploring storage opportunities for several years and has used a recent proposal as a "sample storage project" for the analysis that follows.

Two prices were evaluated. The prices were based on whether the battery would be solely for BED's use (referred to as "full tolling" and carrying a higher price) or would be shared with the developer (referred to as "partial tolling" and carrying a lower price but potentially reducing some value streams and leaving other value streams with the developer). A partial tolling agreement would essentially limit BED to focusing on reducing transmission and capacity costs. Such an arrangement also would require advance notice from the developer to dispatch the battery and inject energy into the grid, thus limiting BED's ability to react to higher than forecasted loads and the battery's value. A full tolling arrangement would allow BED to control the battery in real-time, enabling BED to attempt to capture whatever value stream was most advantageous at that time. Furthermore, unexpected market rule changes that shift value from one value stream to another would likely be easier to adapt to in a full tolling arrangement.

This potential project would be "behind the meter" from ISO-NE's perspective, so ISO-NE would not control it for the purposes of energy dispatch, but it would be "in front of the meter" from BED's perspective as it would not be behind a customer meter. Rules related to the treatment of BTM assets are currently in flux, however, as discussed further below.

The type of tolling, full or partial, affects the probability BED would assign to the storage asset of being able to realize capacity and RNS savings (under current rules). The more hours BED can use the battery, the higher the probability of achieving RNS savings, which are based on a utility's load at the time of the Vermont peak (for Vermont utilities). The probability of achieving capacity savings does not materially change over time (between tolling options), as we assume available dispatch hours would be focused first on achieving capacity savings, which are currently monetarily larger and based on a single annual peak hour. RNS savings[2] would be pursued to the extent that additional energy storage is still available. This would remain true for the foreseeable future because even at very low capacity market prices, the

[1] Bear Swamp and Northfield Mountain

[2] RNS values are based on separate values for each month.

value of 12 months of capacity savings would still exceed the value of one or more months of RNS savings.

Table 1. Assumed Storage Prices and Peak Discharge Likelihoods

Tolling	Price	RNS Likelihood	FCM Likelihood	Notes
Full	$17/kW-month	9/10	29/30	
Partial	$11/kW-month	2/3	19/20	Day-Ahead dispatch; 400 discharge hours per year; discharge must be called either the day before for the next morning or the in the morning for nighttime discharges; BED does not receive any frequency regulation revenues

Project Cost

The bulk of the modeled project costs are associated with PPA, with lesser costs related to the electricity use to recharge the battery (including losses incurred in the charging/discharging cycle, which are assumed at 15% for this project).

Project Value

The value of a battery storage project would depend upon its proposed uses. The value of each use can be further categorized as: the value of a particular use or "value stream," ability to capture that value stream, and the impact on BED's risk profile (due to BED's exposure to risks associated with that value stream). Below, the Transmission, Frequency Regulation, Capacity, and Energy value streams are examined in detail as the primary value streams that can be realized under current ISO-NE market rules. Any particular battery project might, especially in the future, be able to avail itself of additional value streams[3] (and BED would include those in an analysis of a particular project), but the value streams included in this analysis should be available to most projects.

It is important to note that in the case of multiple value streams, consideration is given to the potential that there could be conflicts between what is needed to realize two or more

[3] https://rmi.org/wp-content/uploads/2017/03/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport-FINAL.pdf, accessed August 2020.

value streams. For example, a battery discharged for an anticipated ISO-NE peak hour might not be available to discharge again for a Vermont peak hour that occurred later the same day.

Transmission Value Stream (ISO-NE RNS)

By discharging the battery during the hour of Vermont's monthly peaks, under current treatment of loads, BED would reduce its pro rata share of transmission charges that are based on those peaks because energy discharged locally from the battery would lower BED's recognized demand. The amount of societal value that BED could create through those discharges is less clear because those transmission costs would still be paid by other market participants. If the reduction in BED's load that resulted from battery discharges during monthly peaks postponed the need for development of additional infrastructure, the societal savings could be relevant and material, but the transmission deferral value of a particular project on RNS would be difficult to estimate.

Price/Value

As discussed in the Financial Assessment chapter, RNS transmission costs have approximately quintupled from 2005 to 2020, and the IRP forecasts that they will continue to increase. The current price of transmission ($129/kW-year) is almost equal to the cost of the proposed partial tolling PPA option ($132/kW-year). To the extent that BED is able to discharge the battery during each monthly peak, the transmission savings alone would almost immediately cover the bulk of the project costs provided there are no changes in the load treatment (see risk discussion).

Availability

Transmission savings would be achieved by discharging the battery during the Vermont monthly peak hour. The partial tolling option would require BED to give the developer some amount of advance notice that BED would need to use the battery for discharging and would limit the number of hours that BED can discharge the battery to 400 annually, while the full tolling option would allow BED to discharge the battery in real time and frequently if needed. The availability of transmission savings was then assumed for each tolling option based on our experience predicting peaks relative to the advance notice required and hours available for BED's use.

Since late 2018, BED has been using a model to predict[4] VT and ISO-NE peak load. BED used this model and its experiences to date with its Defeat the Peak program to evaluate the relative desirability of the proposed partial tolling options. It was determined that 360 hours out of the 400 hours proposed in the battery system contract could be used for battery discharge to avoid monthly peaks with 40 hours being reserved for New England annual peaks. In 2019, 8 of

[4] BED ran the model on 183 days in 2019.

12 monthly peaks were contained in the 360 hours, with the highest likelihood of being a peak as calculated prior to the day of the peak. Based on this data, BED assumes that it will be able to coincide battery system discharge with monthly Vermont peaks two-thirds of the time, so for this analysis partial tolling is expected to capture two-thirds of the Vermont monthly peaks. This rate is hopefully conservative relative to actual practice, where BED would be able to examine the probability of a peak somewhat closer to the peak and apply additional data sources and expert judgment (rather than relying on a single model).

Based on our experience with Packetized Energy's virtual battery, full tolling will be able to discharge during 90% of monthly VT peaks. The Packetized Energy program achieved a higher success rate of timing battery discharge with Vermont monthly peaks in part because the batteries operate without restrictions on number or duration of peak "discharges." Consequently, under the Packetized Energy program BED has successfully reduced usage during monthly peaks every month since we began regularly updating our peak events in August 2019.

It is possible that as DERs capable of flattening Vermont's (and the region's) load are deployed, predicting the peak, and when to discharge a battery, will become more difficult. Continued deployment of solar, if not reconstituted, will continue to lower loads when the sun is out, making peak prediction somewhat easier (due to many daylight hours being much less likely to be the peak).

Risk Profile Impact

BED is a buyer but not a seller of ISO-NE transmission services because these charges are assessed under a tariff structure vs. a locational buy-sell market structure (as with energy, capacity, and regulation, among others), so any action that reduces transmission usage and costs will reduce our exposure to RNS price fluctuations. However, a large risk exists that the structure that allows for load reductions to create this value stream will be changed or even abolished. ISO-NE's internal market monitor is currently advocating for "reconstituting" (adding back) BTM generation for the purposes of calculating network load.[5] It is unclear what impact, if any, this will have on BTM storage, but in the worst case, it would the transmission value stream would be eliminated entirely (*as is illustrated by figures 3a-d, the loss of all transmission value would result in the storage option providing no net value to BED under either partial or full tolling*). This represents a key risk to the present consideration of the value of storage.

[5] https://www.iso-ne.com/static-assets/documents/2020/07/2020-spring-quarterly-markets-report.pdf, accessed August 2020.

Frequency Regulation (Automatic Generator Control) Value Stream

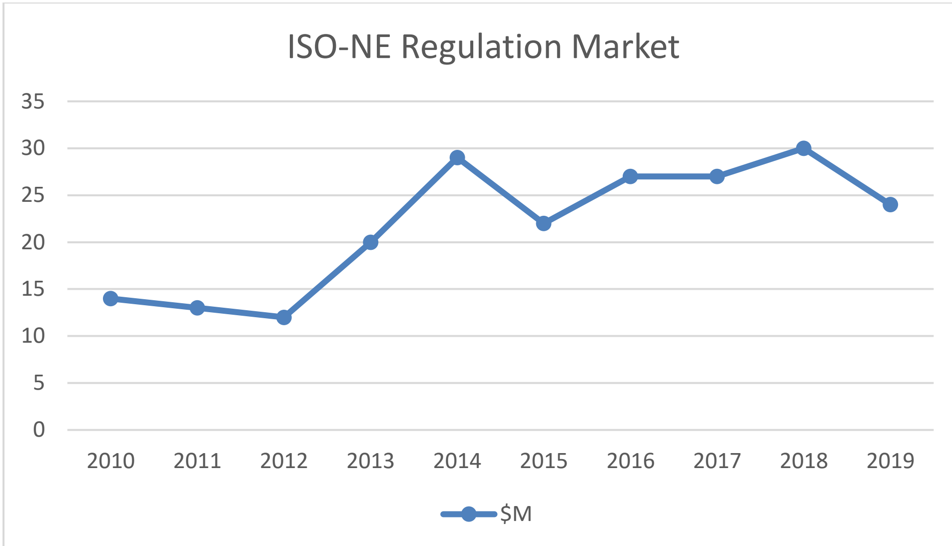
Market participants can earn Frequency Regulation (or Automatic Generator Control ("AGC")) revenue by allowing their assets to be controlled on a second-by-second basis by ISO-NE to balance small changes in supply and demand on the grid.[6] BED currently incurs regulation charges based on its share of ISO-NE's hourly load. A BTM storage resource could register with ISO-NE as an Alternative Technology Regulation Resource for the purpose of providing regulation. This value stream would only be available to BED under a full tolling structure due to the battery being in New England and greater than 1 MW.

Price/Value

The price of regulation services is difficult to predict. The increase in intermittent resources could result in additional regulation services being procured by ISO-NE, likely increasing the regulation price. Currently, ISO-NE is procuring less than 100 MW of regulation service on average,[7] and with more than 2 GW of battery storage in ISO-NE's queue, it seems possible that the number of potential suppliers of this service will grow such that the revenue received for providing will fall to the marginal cost of providing it with a battery. If the value of AGC services were to fall to that level, BED and others would not receive any additional net revenues as the value of providing the service would equal the cost of providing it. As shown in Figure 1, the size of the regulation market has remained small relative to the billions of dollars that are exchanged for energy and capacity in New England every year.[8,9]

[6] https://www.iso-ne.com/markets-operations/markets/regulation-market/, accessed August 2020
[7] https://www.iso-ne.com/static-assets/documents/2020/05/2019-annual-markets-report.pdf, accessed August 2020
[8] https://www.iso-ne.com/static-assets/documents/2017/04/20170411-webinar-energy-storage.pdf, accessed August 2020
[9] https://www.iso-ne.com/static-assets/documents/2020/05/2019-annual-markets-report.pdf, accessed August 2020

Figure 1. ISO-NE Regulation Market Revenues



The prices assumed in this analysis are a base case based on GMP's Panton battery filing (in Docket 17-2813-PET), a high case of 150% of those values, and a low case starting at the same point as the base case but falling to 0 by 2030. GMP values are used for this analysis given GMP's greater experience in the AGC markets.

Availability

Under a full tolling structure, this AGC value stream would be available to BED whenever the battery was not being used for the other purposes described here; in the partial tolling case it would be unavailable. Using the battery for the AGC value stream may conflict with the battery's use for greater value stream propositions in some cases.

Risk Profile Impact

Deploying a storage asset of this size would reverse and increase BED's exposure to AGC price fluctuations. BED is currently only a buyer of AGC services (i.e., 100% short), having no assets capable of providing those services to the market and is adversely affected when prices for the service increase. With the proposed storage project, BED would become substantially (~300%) long (i.e., a net seller of the AGC service), and therefore adversely affected by falling AGC prices, if it were providing 4MW (5MW * 80% assumed availability) of average service to ISO-NE.

Capacity Value Stream

Under current rules, by discharging the battery during the hour of ISO-NE's annual peak, BED would reduce its pro rata share of capacity charges that are based on those peaks. The amount of societal value that we would be able to create through those discharges is perhaps lower, as the immediate impact would be to shift those costs to other market participants. In the longer term, the reduced load would likely lead to ISO-NE taking actions to "offload" excess capacity in the periodic reconfiguration auctions and less capacity being procured in future FCAs. ISO-NE could adjust future capacity auction procurements, as with EE and BTM solar, by directly modeling the impact of BTM storage in its forecast of required capacity.[10]

Price/Value

Currently capacity represents the second largest value stream available to the proposed storage project (after RNS transmission). The price of capacity has fallen in the last five ISO-NE capacity auctions, but it remains a significant cost driver for BED. Capacity prices are essentially known through May 2024 but could vary substantially in the future.

Availability

BED has consistently been able to identify capacity peaks (i.e., the hour that will ultimately be determined to have been the ISO-NE peak hour for the year) both in its prior demand response program with EnerNOC and its current Defeat the Peak program.[11] For the purposes of this analysis, we assumed that we would be able to time discharges coincident with 19 out of 20 peaks under the partial tolling structure and 29 out of 30 peaks under the full tolling structure. No current discussion is occurring that would remove the availability of the capacity value stream, but as noted above the price is uncertain.

Risk Profile Impact

BED is currently "short" capacity (see Supply Chapter) and will be adversely affected if capacity prices increase in future FCAs, so any action that reduces that exposure will reduce our risk exposure to price increases, provided that BED does not add so much capacity that it becomes a net provider of capacity to ISO-NE (which is very unlikely).

Energy Value Stream

BED could create arbitrage value from an energy storage project by charging during low-priced times and discharging during high-priced times, reducing its net energy charges. This can create value as long as the differences in energy prices between the discharge and charge times are sufficient to justify incurring the energy losses incurred in the cycle. To the extent that discharge times for capacity and transmission might not always coincide with the highest price energy times, there could be some overlap between this value stream and the others.

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[10] https://www.iso-ne.com/system-planning/system-plans-studies/celt/, accessed August 2020

[11] http://burlingtonelectric.com/peak, accessed August 2020

Price/Value

Although energy prices vary on a five-minute basis in the ISO-NE wholesale markets, on most days they do not vary greatly, and as a BTM resource this resource would be settled hourly with BED's load. Accordingly, the price assumption is based on BED's existing forecasts of on-peak and off-peak price spreads.

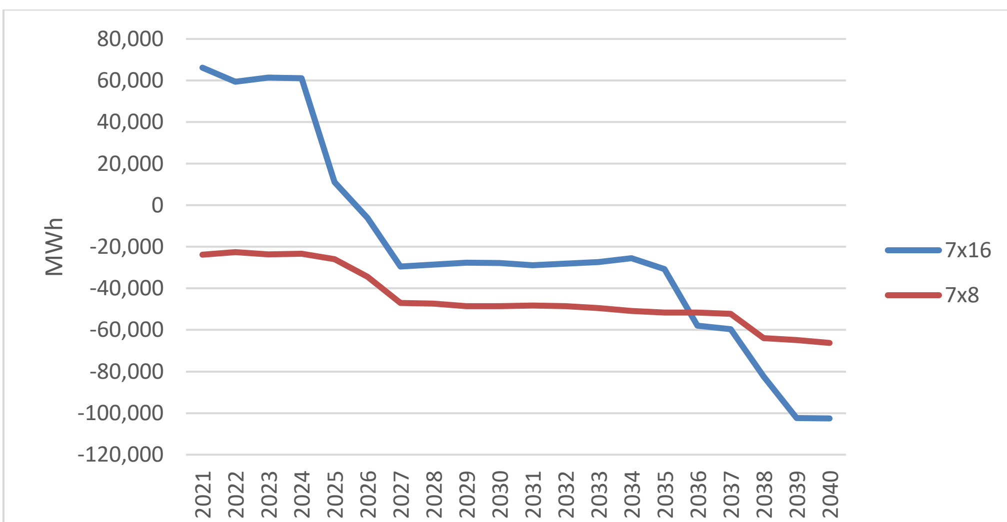
Availability

This analysis assumes that the energy arbitrage would occur around attempting to lower peak costs and, specifically, that on-peak energy usage would be reduced by 400 hours * 5 MW or 2,000 MWh per year.

Risk Profile Impact

As shown in Figure 2, BED is projected to be longer (or less short) in the "x16" hours (7:01am-11pm) than in the "x8" hours (11:01pm-7am) through 2035. As the battery would likely shift load from the x16 hours to the x8 hours, it would exacerbate this issue. That said, given the small net impact to BED's energy position (through round-trip and standby losses), BED is not likely to be taking on significantly more, or shedding much, energy price risk. Additionally, if there are hours with higher and lower prices, a battery can recognize them whenever they occur, not just in the ISO-NE defined "peak" and "off peak" periods.

Figure 2. Energy Position by Time Block



Results

As part of its examination of the storage project, BED performed a cost/benefit comparison of the project at our high, base, and low variable values to the project's costs. This comparison showed that the project would have little impact on BED's NPVRR at our expected prices but would be substantially profitable at higher prices. A series of sensitivity tests were performed, showing that, apart from using the battery for frequency regulation, the project would generally reduce BED’s risk to market fluctuations because of the reduction in our capacity shortfall and transmission exposure. Additionally, potential rate pressures were calculated with and without the project, showing the main financial impacts to be in the 2030s due to continued projected increases in transmission prices.

Cost/Benefit

To perform the cost/benefit tests, BED added a storage-specific “mini-model” to our standard IRP 20-year financial model. BED then looked at the value of the project at each of the high, base, and low values for the major value streams identified. This showed the most significant potential value streams of the battery project to be transmission cost reduction as well as frequency regulation market participation and capacity savings. Energy arbitrage is smaller and less likely to be a major driver of the project’s economics unless the spread between the highest and lowest prices in a day widens. The cost/benefit analysis also revealed that there is significant risk (both upside and downside) in this project. This risk is driven by both by the different price cases (particularly with regard to capacity) as well as the possibility of the transmission value stream being lost to load reconstitution.

Figures 3a-3d below illustrate the five- and twenty-year cost/benefit analyses. The five-year analysis is presented to consider the impacts during the period where the capacity prices are relatively certain. The effect of the current three-year forward capacity structure can be seen more clearly in the reduced range of potential capacity revenues between the three cases. Note that BED has not been offered a five-year tolling arrangement under a PPA, but one of the theoretical advantages of storage is its modularity and relative ease of deployment (both of which potentially argue against deploying unneeded storage materially in advance of its becoming economical).

Figure 3a. 20-Year Partial Tolling NPV

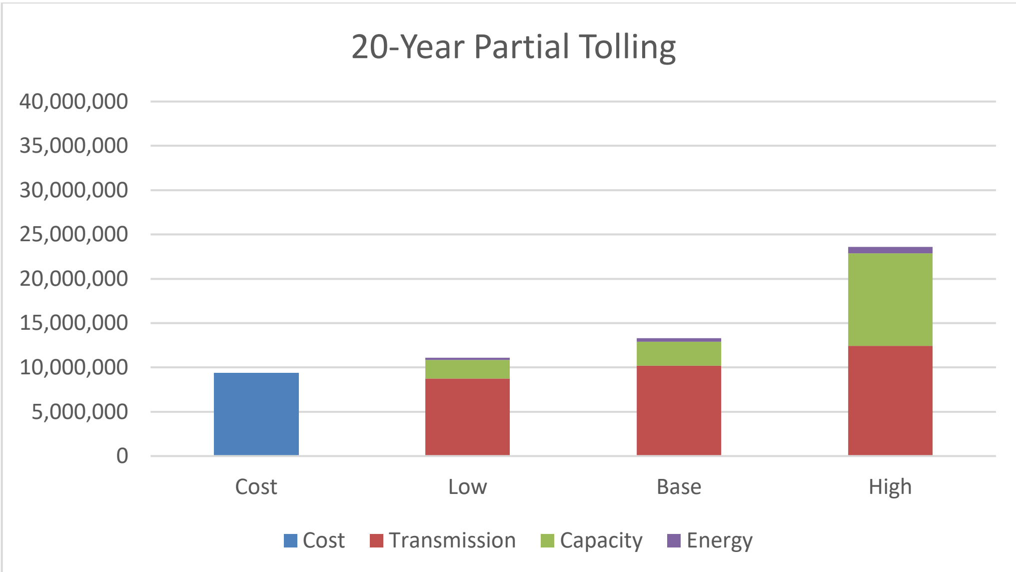


Figure 3b. 20-Year Full Tolling NPV

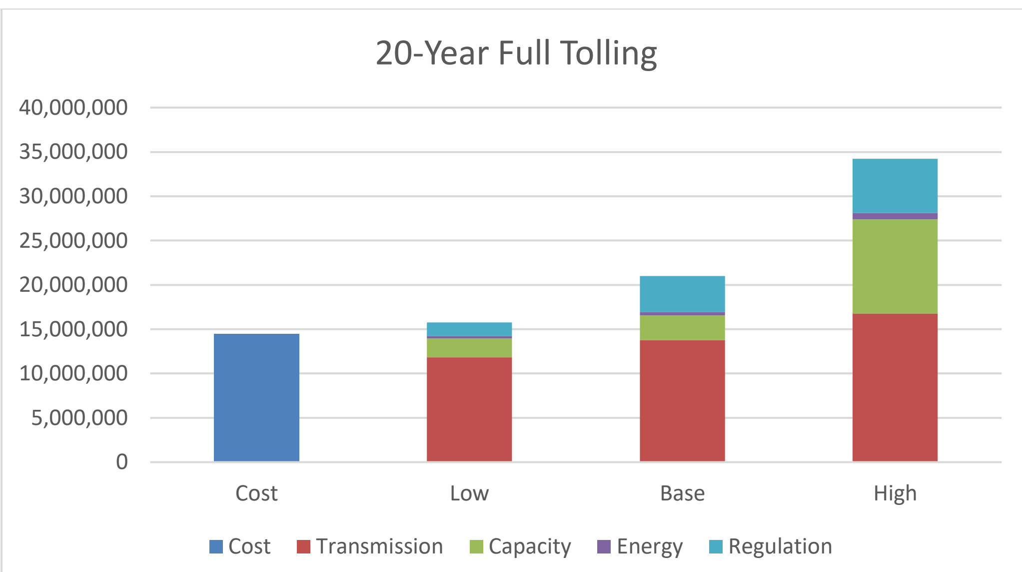


Figure 3c. 5-Year Partial Tolling NPV

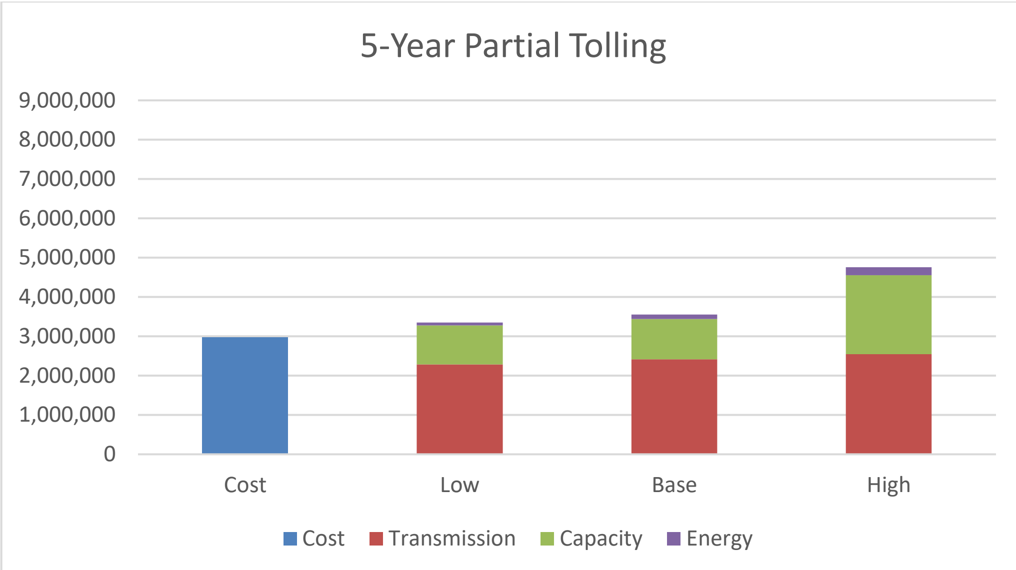
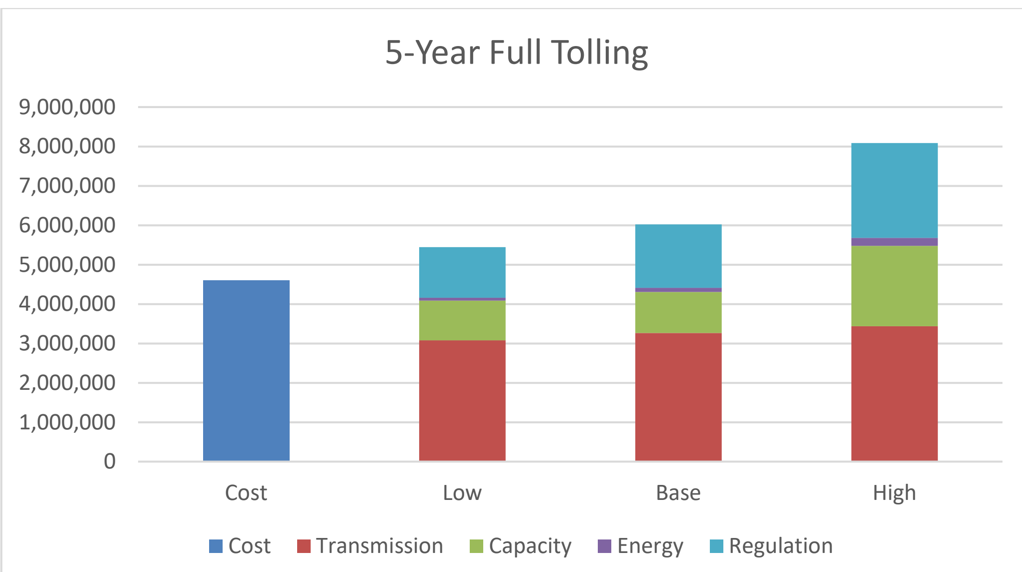


Figure 3d. 5-Year Full Tolling NPV



Sensitivities

To perform the sensitivity tests, BED calculated the NPV of our five- and twenty-year cost of service without storage (i.e., the NPVRR), with a partial tolling PPA, and with a full tolling PPA. The resulting tornado charts (Figures 4a-4f) show a comparison of the NPVs with low, base, and high values for each variable. Based on these charts, it appears that this project would reduce BED's risk of exposure to swings in capacity prices (particularly over the twenty-year horizon) and, if load is not reconstituted as proposed by ISO-NE, it would also decrease BED's transmission price risk. Participation in the project would increase BED's risk to frequency regulation prices and load reconstitution.

Figure 4a. 20-Year Full Tolling Tornado Chart

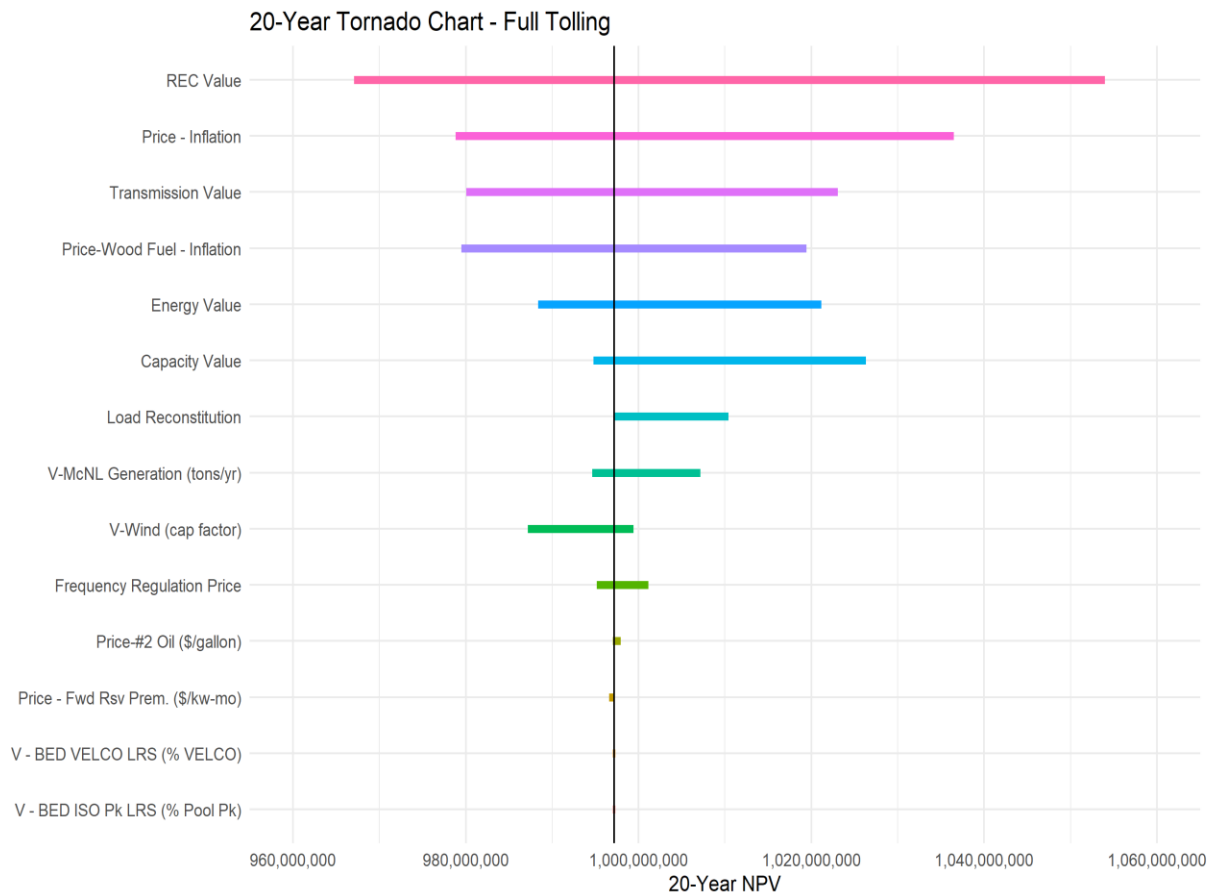


Figure 4b. 20-Year Partial Tolling Tornado Chart

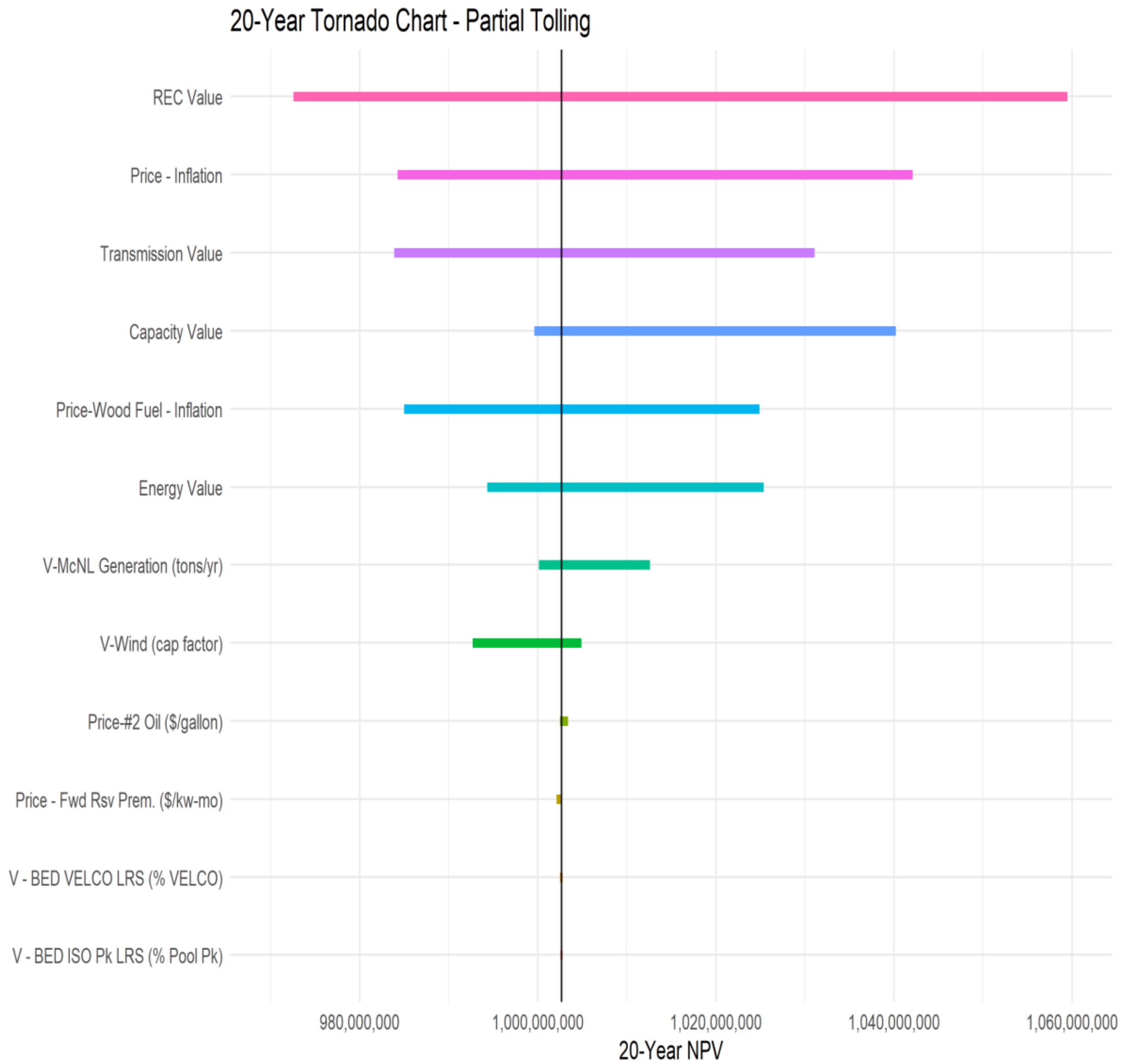


Figure 4c. 20-Year Base (No Storage) Tornado Chart

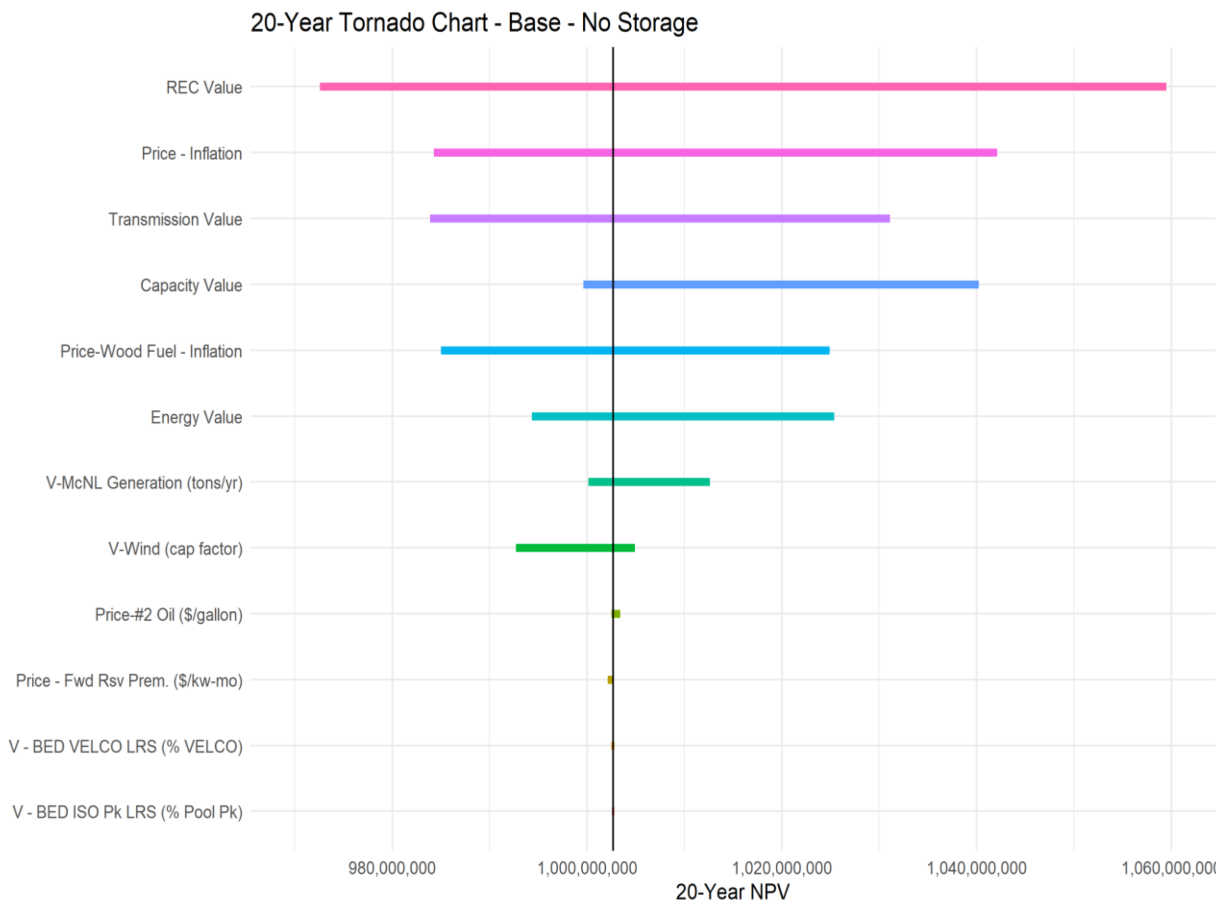


Figure 4d. 5-Year Full Tolling Tornado Chart

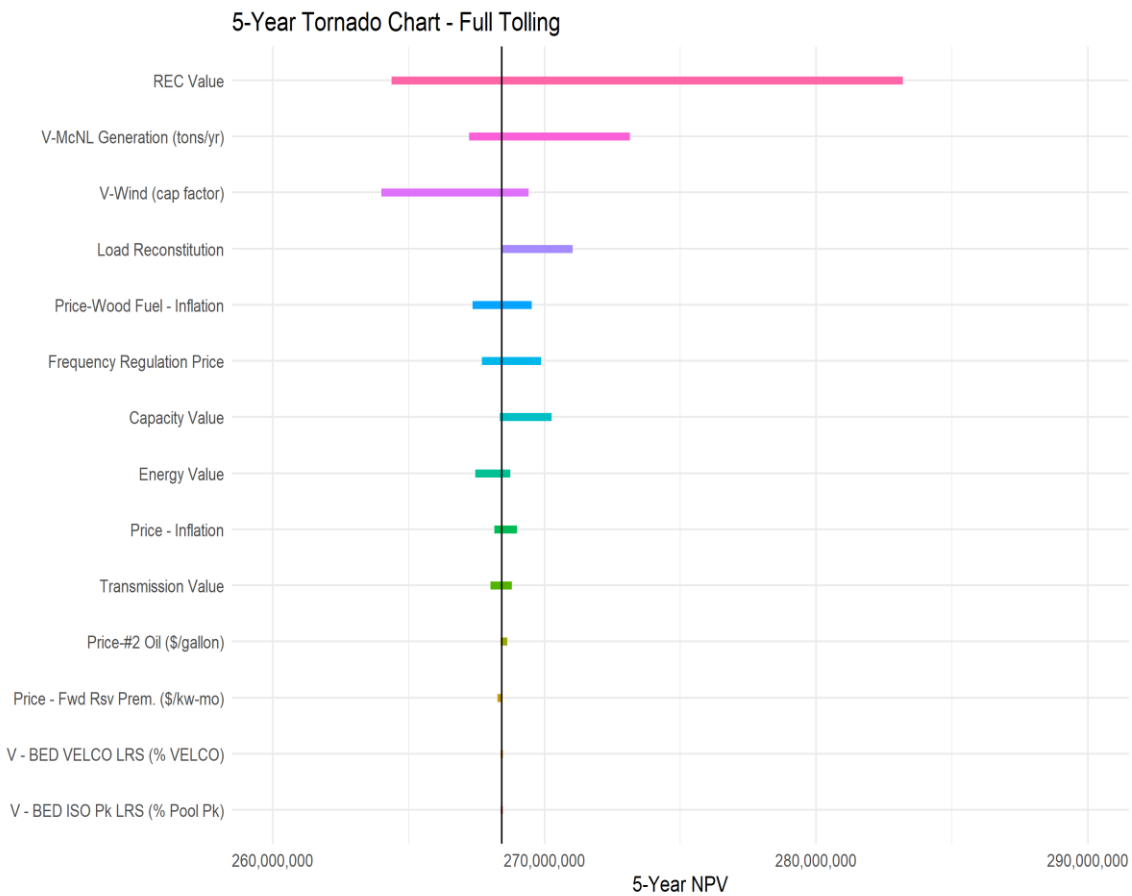


Figure 4e. 5-Year Partial Tolling Tornado Chart

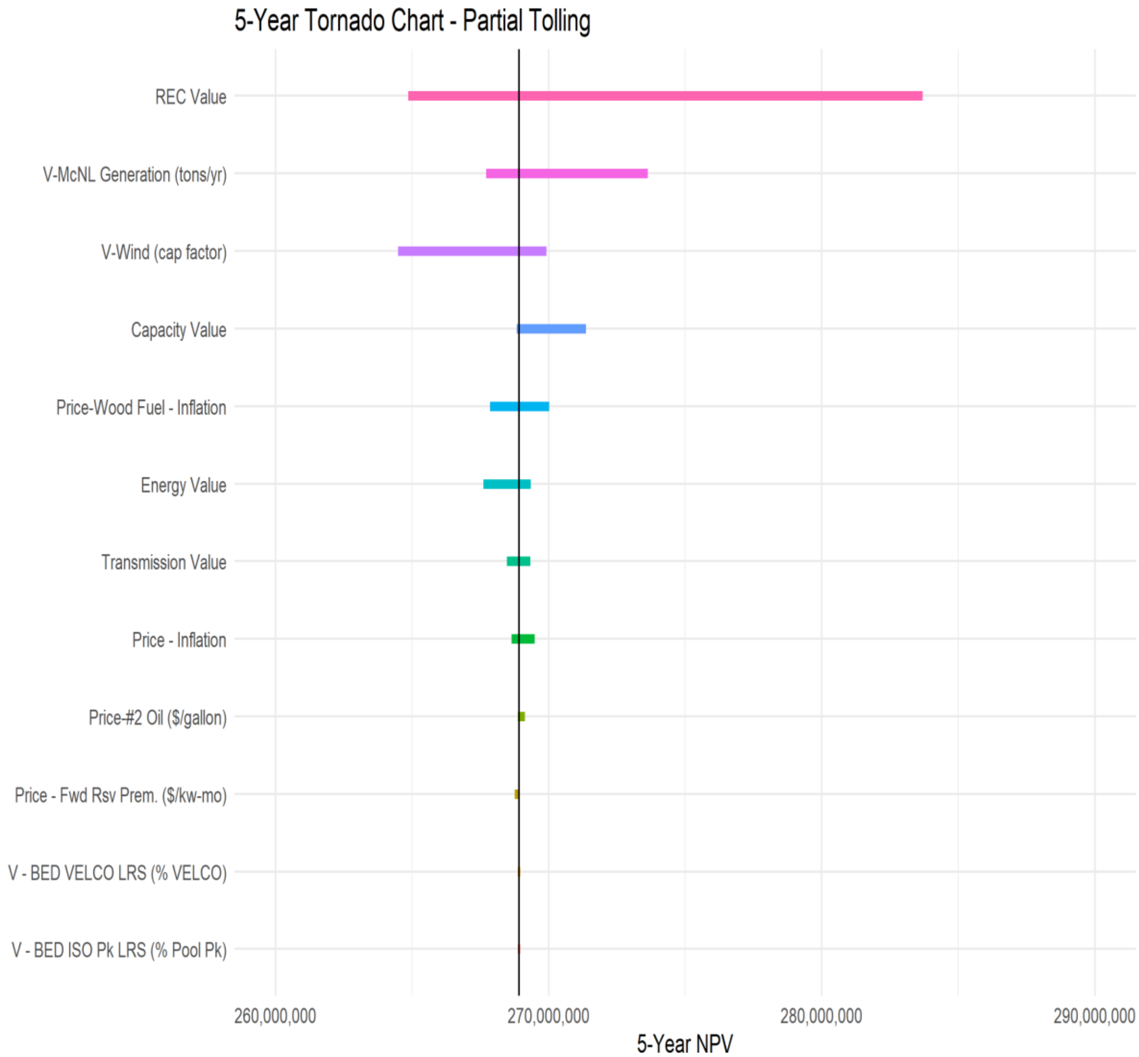
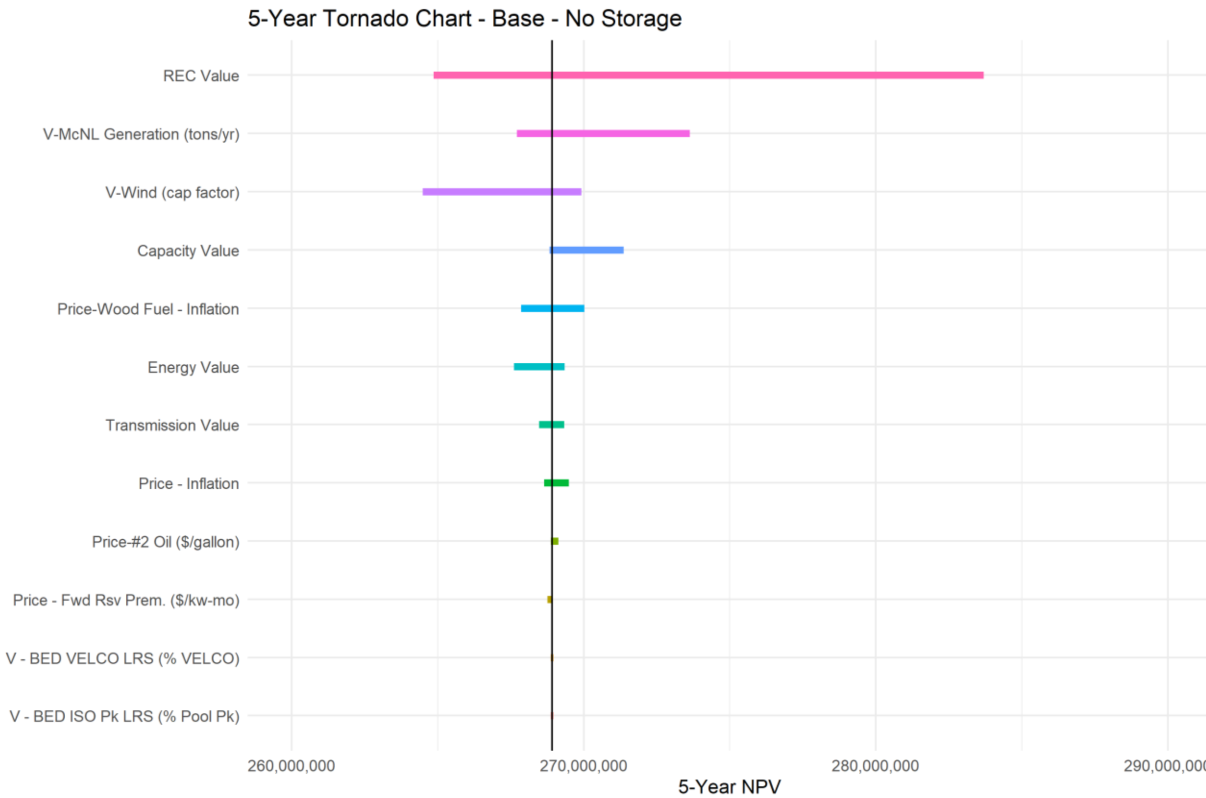


Figure 4f. 5-Year Base (No Storage) Tornado Chart



In addition, as shown below in Table 1, the spread of values between the two PPA options and the "do nothing" option shows a shrinking of transmission and capacity risk assuming no load reconstitution (i.e., no loss of the RNS value stream).

Table 1. Delta between Low Transmission and Capacity Prices Case v. High Transmission and Capacity Prices Case

	5-year	20-year
Base (No Storage)	3,394	87,815
Partial Tolling	2,717	75,760
Full Tolling	2,686	74,508

Tables 2 and 3 provide the range for a larger number of variables and a comparison of the impact of the battery options on those ranges.

Table 2. Delta between High and Low Values NPV by Tolling Case

	5-Year High/Low Delta			20-Year High/Low Delta		
	Base	Partial	Full	Base	Partial	Full
REC Value	18,828,170	18,828,170	18,828,170	86,922,188	86,922,188	86,922,188
Price - Inflation	845,554	829,244	827,724	57,801,366	57,651,138	57,634,299
Transmission Value	866,830	809,266	789,118	47,208,006	44,080,611	42,986,022
Price-Wood Fuel - Inflation	2,174,165	2,174,165	2,174,165	39,926,494	39,926,494	39,926,494
Energy Value	1,737,291	1,284,324	1,284,324	31,040,680	32,773,289	32,773,289
Capacity Value	2,527,518	1,907,459	1,896,581	40,607,084	31,678,950	31,522,316
Load Reconstitution	0	1,933,876	2,610,732	0	9,799,439	13,229,243
V-McNL Generation (tons/yr)	5,915,474	5,915,474	5,915,474	12,509,473	12,509,473	12,509,473
V-Wind (cap factor)	5,426,725	5,426,725	5,426,725	12,217,194	12,217,194	12,217,194
Frequency Regulation Price	0	0	2,170,712	0	0	5,947,869
Price-#2 Oil ($/gallon)	252,179	252,179	252,179	894,709	894,709	894,709
Price - Fwd Rsv Prem. ($/kw-mo)	183,891	183,891	183,891	681,171	681,171	681,171
V - BED VELCO LRS (% VELCO)	90,086	90,086	90,086	281,198	281,198	281,198
V - BED ISO Pk LRS (% Pool Pk)	83,085	83,085	83,085	256,658	256,658	256,658

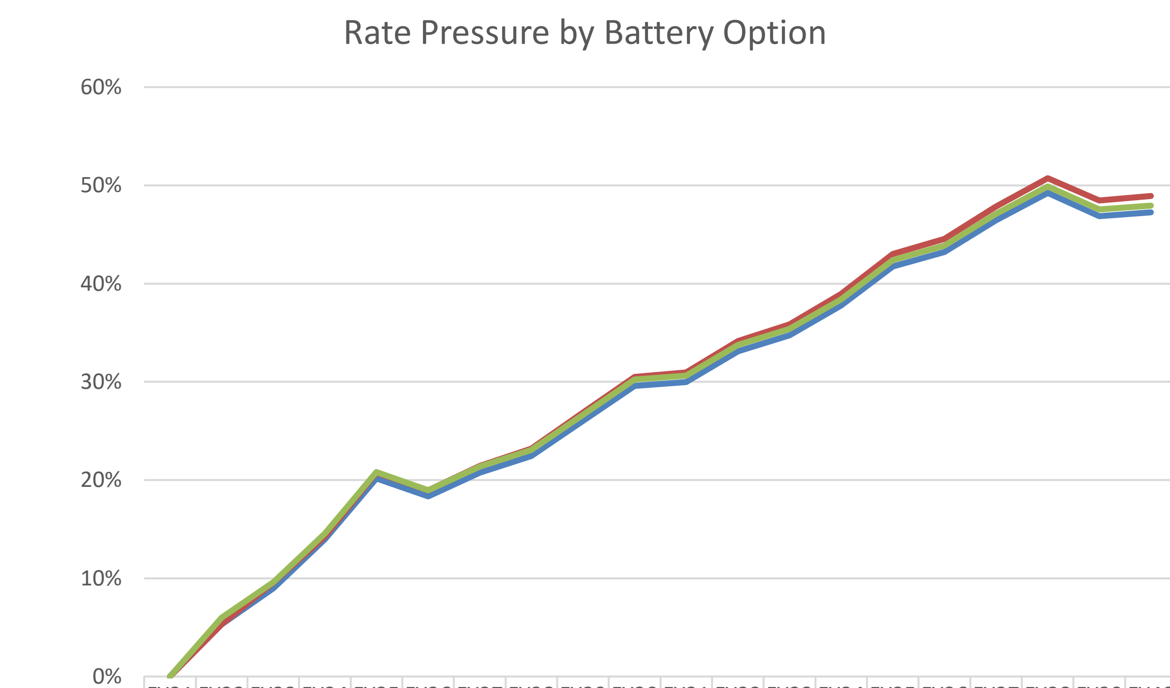
Table 3. Delta between High and Low Values NPV between Tolling Cases

	5-Year High/Low Delta			20-Year High/Low Delta		
	Base to Partial	Base to Full	Partial to Full	Base to Partial	Base to Full	Partial to Full
REC Value	0	0	0	0	0	0
Price - Inflation	-16,309	-17,830	-1,521	-150,228	-167,066	-16,838
Transmission Value	-57,564	-77,711	-20,147	-3,127,395	-4,221,984	-1,094,588
Price-Wood Fuel - Inflation	0	0	0	0	0	0
Energy Value	-452,967	-452,967	0	1,732,609	1,732,609	0
Capacity Value	-620,059	-630,937	-10,878	-8,928,134	-9,084,768	-156,634
Load Reconstitution	1,933,876	2,610,732	676,857	9,799,439	13,229,243	3,429,804
V-McNL Generation (tons/yr)	0	0	0	0	0	0
V-Wind (cap factor)	0	0	0	0	0	0
Frequency Regulation Price	0	2,170,712	2,170,712	0	5,947,869	5,947,869
Price-#2 Oil ($/gallon)	0	0	0	0	0	0
Price - Fwd Rsv Prem. ($/kw-mo)	0	0	0	0	0	0
V - BED VELCO LRS (% VELCO)	0	0	0	0	0	0
V - BED ISO Pk LRS (% Pool Pk)	0	0	0	0	0	0

Potential Rate Pressure

Finally, illustrative potential rate pressures (as well as the difference between those rate pressures) were calculated with and without the project. As shown below, the project will not be the main driver of rates going forward but could mitigate rate pressure in the 2030s under either the full or partial tolling arrangement (see Figure 5b for a more detailed representation of the differences between the lines in Figure 5a). The rate pressure paths shown in Figures 5a and 5b assume continued RNS value.

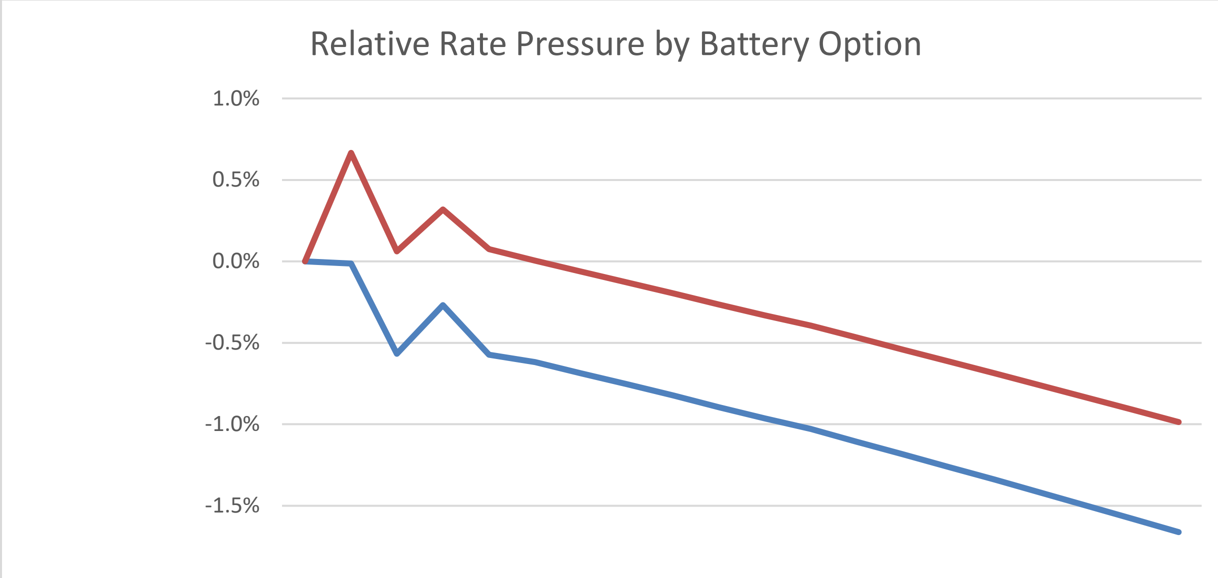
Figure 5a. Rate Pressure by Battery Option



	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	FY36	FY37	FY38	FY39	FY40
Full	0%	5%	9%	14%	20%	18%	21%	22%	26%	30%	30%	33%	35%	38%	42%	43%	46%	49%	47%	47%
Base	0%	5%	10%	14%	21%	19%	21%	23%	27%	30%	31%	34%	36%	39%	43%	45%	48%	51%	48%	49%
Partial	0%	6%	10%	15%	21%	19%	21%	23%	27%	30%	31%	34%	35%	38%	42%	44%	47%	50%	48%	48%

Full Base Partial

Figure 5b. Relative Rate Pressure by Battery Option



	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	FY36	FY37	FY38	FY39	FY40
Base to Full Tolling	0.0%	0.0%	-0.6%	-0.3%	-0.6%	-0.6%	-0.7%	-0.8%	-0.8%	-0.9%	-1.0%	-1.0%	-1.1%	-1.2%	-1.3%	-1.3%	-1.4%	-1.5%	-1.6%	-1.7%
Base to Partial Tolling	0.0%	0.7%	0.1%	0.3%	0.1%	0.0%	-0.1%	-0.1%	-0.2%	-0.3%	-0.3%	-0.4%	-0.5%	-0.5%	-0.6%	-0.7%	-0.8%	-0.8%	-0.9%	-1.0%

Conclusion

As shown above, a single decision can be analyzed in several ways. This analysis of a sample storage project showed that it could have different impacts on BED's bottom line as well as different societal impacts depending on future prices, the availability of value streams, and PPA terms. As the graphs above indicate, a 5 MW storage PPA appears to be a desirable investment (under either a full or partial tolling arrangement) based on currently available information (it results in decreased rate pressure over time) using base case assumptions. It also illustrates that: (i) the full tolling option is generally superior to the partial tolling option, (ii) the partial tolling option actually increases rate pressure in the short term, (iii) the full tolling option does not begin to improve rate pressure until year three of the IRP.

However, there are several uncertainties associated with battery storage systems that we know of that are extremely difficult to model and therefore are not shown in our graphs above. For example, both figure 5a and 5b include the continued value from RNS transmission. Given the above analysis, and coupled with the following considerations not reflected in figures 5a and 5b, BED concludes that it would generally prefer a full to a partial tolling arrangement but at the prices evaluated in this IRP it would probably not proceed with the full tolling option at this time due to:

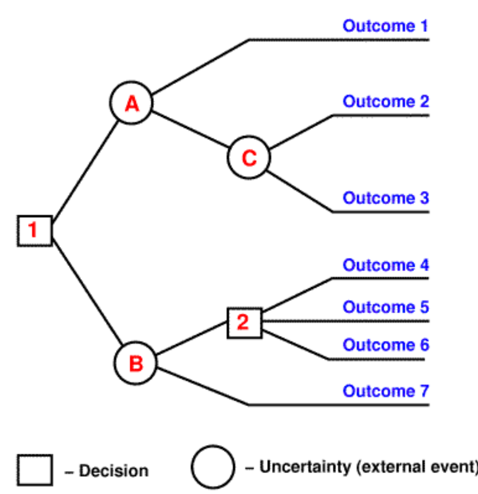
1. Material potential for complete loss of the key RNS value stream (perhaps particularly true for a unit of this size and not located behind a retail meter).
2. Acquiring 5 MW of AGC capability would make BED a material supplier of AGC services relative to its needs, and hence exposes BED to decreasing regulation prices in New England.
3. The concentration of benefit deriving from periods where the FCM price is not known (i.e., three-plus years in the future) coupled with the relative ease and scalability of storage, which argues against installing storage capability prematurely.

Due to these risks, BED's decision making process leads us to the conclusion that postponing decisions related to battery storage is a prudent course of action at this time.

That said, between the 2016 IRP and this one, energy storage systems have made gains in terms of their economics. Thus, BED's decision processes will continue monitoring the applicability of these systems in its service area, especially since the price of battery storage is expected to continue to fall. Also, if ISO-NE clarifies the rules pertaining to RNS value streams such that they are reasonably assumed to continue, or if the FCM market were changed in a beneficial manner, or future FCM clearing prices begin to increase, reconsideration of this conclusion would be warranted.

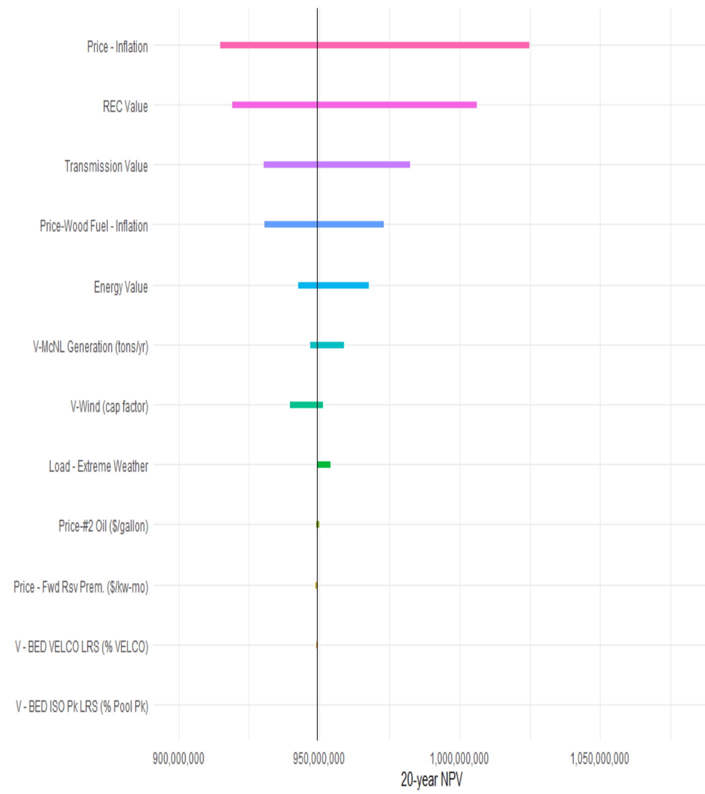
Decision Tree Methodology

On occasion, BED will want to evaluate multiple competing decisions at the same time. A decision tree analysis is a reliable business tool that allows for systematic processing of several input variables or risks that must be evaluated to reach conclusions and make decisions. At its most basic level, a decision tree analysis is a stepwise evaluation of known variables that could materially affect a business's operations if they are not appropriately managed. The diagram to the right highlights such steps, the sequential interactions between decisions and risks, and the plausible outcomes that may follow.



At the start of a decision tree analysis, input variables and other external factors that could impose material risks on decision outcomes are identified.

BED uses tornado charts to further inform its decision tree analyses by graphically highlighting how known risks could impact our cost of service, or net present value of our revenue requirement ("NPVRR"). As shown in the example graphic below, known risks are listed along the vertical axis and the 20-year NPVRR is highlighted along the horizontal axis. The color-coded bars display the range in probability of occurrence of select risks and their corresponding range of impact on BED's NPVRR. In this example, wood fuel inflation is the fourth highest-risk factor because the likelihood of it occurring in the future is speculative (i.e., the wider the bar, the wider the range of probability of occurrence). Similarly, the range of potential impacts caused by higher-than-normal



escalating wood prices on BED's NPVRR is considerable. Through this process of charting individual risk profiles and their potential NPVRR impacts, BED can assess the sensitivity of our NPVRR to various known risk factors. Knowing how sensitive NPVRR is to such risks will inform the selection of a preferred path forward with any future resource procurement decision.

Next, BED assigns a probability of occurrence between 0 and 1 based on the best available information. This risk assignment process is typically performed by management and staff responsible for developing project plans. After each team member assigns their probability of occurrence to a specific risk, a range of potential outcomes for the risk can be determined. For example, one team member could assign the likelihood of higher than forecasted inflation (e.g., 5%) a score of 0.90. Another member could assign the same risk a score of 0.10, indicating that higher than forecasted inflation is unlikely to occur anytime soon. This assignment process reveals that inflation not only has the potential to materially impact operations, but the range of such impacts could potentially swing by 80% in one direction or the other. Such a wide range in probability of occurrence also means that inflation is a high-risk factor that needs to be tracked and managed carefully over time.

To reflect BED's decision-makers' view of risks facing BED, input variables are then weighted to arrive at a weighted-average risk profile. If, for example, two staff members assign the risk of high inflation a score of 0.90 and four staff assign a score of 0.1, then higher than forecasted inflation rates have a 36.67% chance of occurring over the planning horizon. By weighting known risks in this manner, management can gain better insight into the impact on BED of the potential future states that are of the most concern. For example, a consistent weighting of the high energy value by BED decisionmakers would indicate concern that the current energy market conditions are not sustainable. This "weighted case" does not replace, but is additional to, the other cases as a point of discussion along with any non-monetary and risk related considerations. These steps of this iterative process are repeated until a reasonable decision path comes into view.

The step of creating a "weighted" case was omitted in the above storage analysis only because of time constraints. Given the range of results and the very real potential for loss of the RNS value stream to rule changes in the near future, creation of a weighted case would not have been likely to change the conclusion reached.

To summarize, the decision tree process leading to the development of BED's tornado charts follows a series of key, iterative steps. These include:

- identifying, evaluating, and modeling key input variables;
- assigning probability of occurrence scores to key input variables, and calculating their weighted average expected probabilities;
- conducting NPVRR sensitivity analyses;
- identifying and examining answers to key questions that may impact BED's overall mission;
- evaluating plausible scenario outcomes; and
- refining decision tree scenarios and re-evaluating outcomes, as needed.

Conclusion

BED considers any major decision through many "lenses." This chapter walked through a sample decision and described the decision tree process for evaluating multiple simultaneous decisions. At this point, BED continues to pursue its Net Zero Energy goal but does not have any major decisions regarding that Preferred Path to evaluate.